Petroleum Supply, Marine Transportation Technology, and the Emerging International Order of the Post World War One Period

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Abstract At Versailles in 1919 President Wilson described three arenas of economic struggle, mediated by technology and geopolitics, that he saw developing between America and Britain as a new international order emerged: struggles over international transportation, petroleum, and international communication. The case of international transportation, almost all of it maritime in the 1920s, is intimately connected with that of the problem many observers saw with an insecure and possibly faltering global supply of petroleum. America dominated the early period of global petroleum supply, especially after the strike at Spindletop in Texas in 1901, but Spindletop was faltering by 1920. Even before World War One broke out German and British War Aims thus began to focus on the likely oil reserves of the Middle East that America could not control, Germany via the mineral rights the company was granted along the line of the Berlin to Baghdad Railway concession of 1903 and Britain via the Sykes-Picot-Sazanoff agreement of 1916, the latter resulting in the eventual creation of Iraq. In the run-up to the war oil-firing of steam turbine engine warships was seen as a technology that would substantially increase the fighting capacity of naval vessels through, amongst other things, radically easier refueling and a substantial reduction in stokehold crew size. Operators of merchant vessels followed a similar line of reasoning for a new generation of steam turbine powered ships coming to dominate the Atlantic shuttle by virtue of their speed. The war, however, proved a huge technology forcer in the area of diesel engines, which even in their early form were ideally suited to powering merchant ships, offering substantial savings in fuel and/or labor costs over steamships. Commentators in the 1920s were very clear on the relationship between the petroleum and marine transportation struggles, arguing that whoever controlled the right mix of marine transportation technology, in particular that of the merchant marine, and petroleum supply would control the emerging post-war international order. Of the major powers neither Britain nor Germany did particularly well in shifting their merchant

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marines to diesel power, America did very poorly. America's strength was in continuing to control the global oil supply.

Keywords Hegemonic transition • Oil • Naval power • Diesel • Merchant marine

Hegemonic transitions are intimately tied up with geopolitics and, as initially put forward by Mackinder, geopolitical change was driven by technological change (1904). For Mackinder the technologies of the railroad and telegraph shifted the balance of global geopolitics away from the maritime states towards a new generation of land-based states. In such a model changes in transportation and telecommunications technologies were thus clearly significant. In addition, scholars who deal with hegemonic transitions tend to theorize such transitions as culminating in military struggle (for example, Goldstein 1988; Modelski 1978; Tilly 1990; Wallerstein 1974). Such theories pay little or no attention to state type or the polities within them that control state decisions and the impact of those decisions on state behavior, including military and economic struggles. Other crucial decisions concern the development of educational systems and the encouragement or discouragement by state policies of the new technologies that can drive geopolitical shifts. A more complete theory describes three types of transitions between the two main types of states, territorial (land-based) and trading (maritime) states, and includes analysis of the fact that some states contain both trading and territorial polities (Hugill 2005, 2009b).

By 1919 Mackinder had developed his model of geopolitics further and had incorporated into his analysis the problems posed by internal struggles between polities embedded within states: "Berlin committed a fundamental mistake [in 1914]; she fought on two fronts without fully making up her mind on which front she meant to win. Berlin had not decided between her political objectives: Hamburg and overseas dominion [the aim of its trading polity] or Bagdad [sic] and the Heartland [the aim of its territorial polity] and therefore her strategical aim was uncertain" (Mackinder 1919: 154).

In similar vein the American historian, Edward Whiting Fox, would later elaborate his theory of "two Frances," one a trading polity, the other a territorial one, to account for persistent French failure to defeat Britain, a highly focused trading state (Fox 1971).

1 Hegemonic Transitions and Technological Innovations

The last hegemonic transition, which was ultimately between a declining Britain run entirely by a trading polity and a rising America in which the interests of its trading polity predominated, involved multiple other trading and territorial polities and a long period of military struggle, conventionally World Wars One and Two. Overshadowed by that military struggle, which focused mostly on the rise of a

German state run predominately by its territorial polity, a state that created an effective system of higher education designed to force new technologies, was the central and entirely economic struggle between Britain and America. American victory in both the military and economic struggles came from both its (eventual) technological advantages and its ability to shape the global policy environment in a series of treaties and agreements that often emerged out of those technological advantages. America's scientific and technical education lagged badly behind that of Wilhelmine Germany and even behind that of Britain (Hugill and Bachmann 2005), but began to catch up in critical areas such as petroleum engineering and geology in the 1930s. At Versailles in 1919 President Wilson, in evaluating the likely future of international relations, described three technological arenas he believed would dominate the struggle between Britain and America: international transportation, petroleum, and international communication. Between 1944 and 1947 a series of treaties and agreements effectively ended that struggle and resulted in overall but not complete American victory (Hugill 2009a).

Innovations, whether in the form of software as ideas or, more conventionally understood, in the form of hardware, and the transfer or diffusion of those innovations away from their area of origin have geopolitical consequences (Hugill and Dickson 1988; Hugill 1993). "Between 1860 and 1913 . . . attaining and sustaining a position of leadership in the world economy depended largely on the domestication of new technology" (Tuma 1987: 408). Innovatory technologies drive Kondratiev cycles in the economy and two Kondratiev cycles combine to create a world leadership cycle (Modelski 1978). In later work, Modelski and Thompson (1988) tied such cycles to a strongly navalist and technological reading of the history of capitalism, arguing that world leadership cycles were periods in which the power that could afford the world's dominant navy enjoyed global hegemony. I followed this structure of world history in *World Trade since 1431*, arguing that world leadership cycles are better understood as hegemonic cycles and that hegemons have achieved hegemony through commitment to high levels of technological innovation (Hugill 1993, 2003).

Wilson's evaluation at Versailles was prophetic. The economic struggle between Britain and America that began with the Morrill Tariff of 1861 and that was seemingly damped down by the period of rapprochement leading up to World War One broke out with renewed vigor after Versailles, at which point only two powerful actors seemed left standing on the global stage: an up-and-coming America and a British Empire acquiring significant new territories under League of Nations' mandate (Hugill 2009a). Wilson saw maritime transportation as crucial to the struggle over international transportation, stating at the beginning of the war "we have grossly erred in the way we have stunted and hindered the development of our merchant marine. . .and now when we need ships, we have not got them" (quoted in Denny 1930: 350). Unfortunately Wilson failed in three areas. First, he lacked understanding of the remarkable technological changes then underway in the field of marine propulsion systems as triple expansion steam engines gave way to steam turbines and, more significantly, diesel engines. In today's world merchant shipping is almost exclusively powered by diesels (Smil 2010). Second, in 1920

Wilson signed into law the protectionist Jones Act: all goods transported by water between American ports had to be in American flagged, constructed, owned, and crewed ships. Such water routes were usually short haul, around the American coast, through the Panama Canal, and throughout the Caribbean, with long runs only to Hawaii and the Philippines, routes where re-fuelling was easy and the long range of diesels scarcely mattered. The Jones Act could not protect American shipping on long hauls in international waters where the diesel came into its own and by encouraging American ship owners to stay with steam technology worked against America's long-term interests. Third, Wilson failed to see the rapidly increasing importance of the aerial component of international transportation. This was the component of international transportation where, by 1947, America would convincingly out-perform Britain (Hugill 2009a).

Wilson further failed to grasp the intimate connection that had emerged between maritime transportation technology and petroleum supply in the first 20 years of the century, and in 1919 he believed America would continue to dominate the arena of petroleum supply just as it had since the late 1860s. In fact, by the late teens informed observers began to believe that the global supply of petroleum was insecure and theorized "oil exhaustion" was on the horizon, especially in an America that, according to Canadian banker E. Mackay Edgar in an influential comment, had "recklessly and in 60 years run through a legacy that, properly conserved, should have lasted her for at least a century and a half" (Edgar 1919). To observers at the time the link between the struggles over maritime transportation and petroleum supply was also clear: "Britain waged an exhausting war with the main object of ruining German shipping for ever...Yet now, from the very war which destroyed that competitor, a new one has arisen, twice as formidable as the old, for, in addition to a superiority in tonnage, it enjoys the practical monopoly of a fuel of which Britain has none" (Delaisi 1922: 21). In shipping "as a means of raising steam oil was about twice as economical [as coal], and was four times so if used in internal combustion engines" (Mejcher 2007: 8). By the beginning of World War Two about half the world's merchant ships were oil fueled: "of these ships, half were steam and half diesel powered" (Winkler 2003: 145). Despite the gloomy forecasts of oil exhaustion America continued, then deepened its practical oil monopoly in the 1920s and 1930s, but it signally failed to capitalize on the superiority in merchant ship tonnage it had developed during World War One.

2 Global Oil Supply Issues, 1901–1945

This section encompasses three main time periods: from 1901 to around 1919, from 1919 to around 1931, and from 1931 to 1945. In the first period American production predominated, Russia was an important secondary source, with the Dutch East Indies a distant third and Mexico and Rumania coming into play (Table 1). Most contemporaries believed that the Middle East promised a huge though unproven

Table 1 Global oil production, 1861–1941, in 42 gallon barrels (Fanning 1947: 256–259)

Year	Burma	Dutch East Indies	Persia/Iran	Mesopotamia/Iraq	Mexico	Rumania	Russia	Saudi Arabia	USA	Venezuela	World
1861						47			5,791		5,838
1871						247	452		14,260		15,699
1881						334	9,866		75,784		87,652
1891						1,337	94,721		148,746		249,589
1901		10,977			27	4,597	233,337		190,108		458,740
1911		33,351			34,392	30,433	181,326		603,969		943,455
1921		47,992	45,679		549,544	23,391	79,364		1,293,652	4,104	2,120,383
1931		93,913	121,578	2,000	90,335	136,900	446,685		2,331,729	325,696	3,764,998
1941	20,959	141,918	138,704	31,632	117,488	109,749	647,000	11,800	3,841,721	625,017	6,075,989

bonanza. The Bolshevik Revolution withdrew Russian oil from the world market after 1917.

In the second period, fears of American "oil exhaustion" arose, especially as mass adoption of the automobile accelerated domestic demand. Throughout the 1920s there was an intense policy struggle over access to the Middle East, which precluded much production but seemed to be resolved largely in Britain's favor both by a series of treaties settling the disposition of the former Ottoman possessions in the region and by the Red-Line and Achnacarry Agreements of 1928 between the major oil producers (Venn 1986; Yergin 1991). The main American company to sign these agreements was Standard Oil of New Jersey. In the third period the discovery and development of two major new fields in Texas allowed American domestic production to skyrocket, production finally began in the Middle East, and new technologies exploited by a company that was not a party to the Red-Line Agreement gave an American company access to Saudi Arabia's massive reserves. This amounted by 1945 to a massive American end-run around Britain's previous and largely policy driven dominance of Middle Eastern oil reserves.

2.1 1901–1919

Before 1901 the main use of petroleum in America was as a replacement for whale oil in domestic lighting and as a source of fuel for other domestic uses, such as cooking stoves. But in the late 1800s it became obvious that it had great potential use in transportation: being burned to develop power directly in the rapidly developing automobile and indirectly to generate steam for electric power plants, shipping, and railroad locomotives. Its direct use was pioneered most heavily in Germany, through the work of engineers such as Nicolaus Otto, who developed a working four-cycle, spark-ignition, gas engine, and in the work of Rudolf Diesel, who theorized a very much more efficient engine using heavy oil and compression ignition. Otto was an empiricist. Diesel was very much a product of the first class technological universities that Germany had begun developing in the late 1800s. In Wilhelmine Germany technological education was based on excellent education in mathematics and science, and that put it, at least temporarily, ahead of such states as Britain and America that lagged in this regard, maintaining a much more empirical educational system for their engineers.

By 1901 all the major industrial states had recognized that petroleum was the coming source of power, especially for the steam engines that powered their navies, but only America and Russia had proven and developed substantial domestic supplies, and only America was a maritime power. Through exploitation of its resources in Pennsylvania, California, Oklahoma, and Texas, and through its invocation of the Monroe doctrine to control the increasingly important resources of Mexico and, after World War One, Venezuela, America completely dominated global oil supply for most of the period before World War One broke out. Only the Russian fields around Baku seemed competitive, and only briefly, between 1898

and 1901 did they exceed American output. The Dutch East Indies was the third main supplier by 1911, but much smaller, and oil from the region was shipped by Shell, a British company that got its start shipping exotic seashells for European collectors. By 1911 Mexico and Rumania had also become as important as the Dutch East Indies. The other powers with maritime interests, in particular Britain, but also Germany, began to search for geostrategically secure sources of oil.

Well before World War One broke out Germany and Britain began to focus on the likely oil reserves of the Middle East that neither America nor Russia could control. The area was already geostrategically important to Britain since the main maritime route from Europe to Asia ran through it via the Suez Canal. Before oil was discovered in the region Germany had begun to contest its control with Britain. This contestation was sharpened by the increasing incompetence and corruption of a collapsing Ottoman Empire that, nominally at least, controlled all of the Middle East except Persia, itself an area of contestation between Britain and Russia as part of the "Great Game." Persia was effectively removed from that contestation when Russia and Britain agreed to the partition of the country into a Russian "sphere of influence," a British sphere, and a neutral zone, in 1907.

The collapsing Ottoman Empire was another matter. By 1900 it was pretty obvious that several Ottoman provinces held significant amounts of oil. British military officers reported on this to the Royal Geographical Society as early as 1886 (Ardagh 1886; Stewart 1886). By 1901 a German technical commission would describe Mesopotamia as a "lake of petroleum" which it would be advisable to develop the break the stranglehold on world supplies held by the Americans (Earle 1923: 15). In 1903 Germany negotiated what amounted to a promise of mineral rights in Ottoman territory along the line of the Berlin to Baghdad Railway (BBR) concession, though the BBR never fulfilled its obligations to the government. These rights focused on the three Ottoman provinces that made up Mesopotamia: Mosul, Baghdad, and Basra, modern Iraq. As the Ottoman Empire collapsed and was superseded by the Turkish state, the German interest in BBR evolved into a partnership with Britain in the Turkish Petroleum Company (TPC) of 1912, but the Turks had not approved any concession before war began in 1914 (Earle 1924).

Britain's interests were convoluted. Their focus on the Middle East began with the D'Arcy concession of 1901 from the Shah of Persia, which evolved after the 1907 rapprochement with Russia into the Anglo-Persian Oil Company (APOC) of 1908. In searching for a geostrategically secure source of oil within the Empire Britain first focused on Burma, but Burma's oil was waxy and became almost solid at North Sea winter temperatures. The Burma Oil Company was re-formed in 1908 as APOC, and Britain's interests then ran through the effective merger of APOC with TPC and BBR in 1912 into the secret agreement signed by Sykes, Picot, and Sazanoff of 1916 dividing the former Ottoman provinces among Britain, France, and Russia when the war ended. When Russia left the war this became Sykes-Picot, and it amounted to a French agreement to cede to Britain the Ottoman provinces of Baghdad and Basra and a significant part of Mosul, including all its oil resources, expanded just before Versailles to all of Mosul (Fitzgerald 1994). This resulted in the creation of Mesopotamia under League of Nations mandate after the war was

over and, after Britain took the TPC as a war prize, the alignment of APOC with TPC (Fromkin 1989; MacMillan 2001). Burma, Persia, and Mesopotamia produced no oil before World War One and only Persia much before World War Two (Table 1).

The massive strike at Spindletop in Texas in 1901 secured America's position as the dominant global producer, with a threefold increase in production 1901–1911 and a doubling from 1911 to 1921. American oilfields before 1901 were, for the most part, developed and marketed by Standard Oil and its associated companies. But Standard Oil failed to see Spindletop's potential and, in fact, thought of it as a fluke. Petroleum engineering did not yet exist as a discipline and the company's geologists, all trained as hard-rock mining engineers, believed oil was only found trapped in the folds of porous sandstones or in fractured rocks such as limestones. Spindletop's oil was trapped in a salt-dome and it was not until the 1930s that geologists at Louisiana State University and companies such as Standard Oil of California (SOCAL) began to understand such structures. SOCAL had been broken away from Standard Oil proper by anti-trust legislation in 1911 and had gone very much its own way.

2.2 1919–1931

Following French complaints that they had been denied Mesopotamian oil, especially after the cession of Mosul, the British agreed at San Remo in 1920 to cut the French in for 25 % of the TPC. An important consequence of San Remo was that Britain and France between them effectively excluded American companies from the Middle East. This pushed Standard Oil of New Jersey into fomenting a storm of American diplomatic protest that eventually forced Britain into giving American signatories to the Red-Line Agreement of 1928 a further 25 % share in TPC. That still left Britain with rights to all of Persia's oil via APOC and half of Mesopotamia's via TPC, which changed its name to the Iraq Petroleum Company (IPC) in 1929. By 1931 it seemed that such policies would allow Britain to control much of the oil of the Middle East (Fromkin 1989). An important innovation in Britain by 1910 was the development by John Cadman at Birmingham University of Petroleum Engineering as an academic discipline, but Cadman was trained as a hard-rock mining engineer and thus had the same shortcomings as the geologists at America's Standard Oil.

One of the main problems in the early period of oil exploitation, basically through 1931, was that there was no proration policy to protect landowners from reservoir depletion by their neighbors. Massive numbers of wells could be drilled in close geographical proximity based simply on possession of title to the land. This first came to a head in America when the output from Spindletop dropped in the late teens from massive over-drilling. In 1917 the Texas Railroad Commission began controlling oil and gas production via its regulation of pipelines as common carriers and in 1919 it expanded well spacing to reduce fire hazards. In 1930 it adopted its

crucial proration policy (Texas State Handbook 2013; Herald 1957). These were empirical responses uninformed by any science as yet. Most Texas wells were drilled by wildcatters with no academic training. Initially no major companies were involved. More generous well spacing combined with deeper and more careful drilling allowed Spindletop's output to recover somewhat by the mid-1920s but the growth of the American supply was far from certain until the huge East Texas field, the largest oilfield in American history, was discovered in October 1930. The other major Texas field, in the Permian Basin of West Texas, had been explored in the late 1920s, but where East Texas was easily connected into the pipeline hub that Spindletop had created in Houston the cost of connecting West Texas was initially regarded as prohibitive (Flis and Price 1990).

The history of American oil output from 1901 through 1931, especially the substantial increase in output from 1901 to 1921, is pre-eminently the history of Spindletop. But that period also saw considerable concern over the amount of oil available and the rate at which it was being used up as automobile related demand rose. There was no sense of how large the country's reserves might be, merely figures for production and consumption. Although the Oklahoma field helped compensate for lower output at Spindletop in the 1920s and could be easily connected to the Houston pipeline complex, the real recovery came after 1931. The combination of the massive output of the East Texas and Permian Basin fields, conservationist policies, especially that of proration, better survey technologies, better geological understanding developed in the universities of the region, and the development of petroleum engineering as an academic discipline all combined to end fears of American domestic shortages by the mid-1930s. New wells and new production were added faster than old wells were being closed.

Modern understanding of the size and depletion rate of oil reservoirs began with the innovation of well-head logging by the French company, Schlumberger, in 1926, and the development using the accumulated data from well-head logging of the concept of "peak oil" in 1956 by the Houston based geoscientist, M. King Hubbert (Deffeyes 2006). Neither Schlumberger's data nor Hubbert's model were available to inform those worried about the collapse of American output in the period 1919–1931, hence the peculiar potency in that period of the "oil exhaustion" thesis. Modern scholars with modern knowledge dismiss this history and analyze it as a period in which American oil companies were engaged in a "search for markets" (Bromley 1991; Stivers 1982). Yet at the time the Norwegian political geographer, Anton Mohr, could describe the likely coming global conflict over oil resources as *The Oil War* (1926) and noted the potential of the Middle East to rise to dominance over the global oil supply. Mohr's work is one of a substantial series of accounts from the 1920s and 1930s that follow the "oil exhaustion" thesis. These are exemplified by Ludwell Denny's *We Fight for Oil* (1928), which constructed the fight as between Britain and America. They also include a substantial number of French and German works, which took an explicitly anti-British stance (Delaisi 1922; Fischer 1926; Hanighen 1934; de la Tramerye 1924; Marcosson 1924; Zischka 1933, 1934, 1939). The first of these accounts was Delaisi's book, published initially in Paris in 1920 as *La Pétrole*. There are two "odd men out" in

this list: Anton Zischka and Frank Hanighen published their books much later than the rest, after the Depression had bitten. Zischka was a Viennese born journalist who later took up with the Nazis and whose writing focused heavily on the role of energy, commodities, and technology in world power, usually from a strongly German perspective. His first book, *La Guerre Secrete pour le Pétrole* (1933) was republished in German in 1934 as *Der Kampf um die Weltmacht Öl* and a second book on oil followed in 1939. Zischka's work is intertwined with that of Hanighen, and hard to disentangle. Hanighen was an American muck-raking journalist and his *The Secret War* was reissued in England under the expanded title of *The Oil War, The Secret War* with Zischka listed as co-author.

2.3 1931–1945

After 1930 American domestic production surged and the struggle over access to Middle Eastern oil came down to a strong British rearguard action fought primarily on the grounds of policy and a remarkable American end-run around British interests on the basis of technology developed in American fields, though actual output in the Middle East was initially slight (Table 1). APOC started to produce oil in the 1930s, but the British were concerned that such oil had to travel through the Suez Canal, which was geostrategically vulnerable. At San Remo the British had ceded the right to the French to build a pipeline to get Mesopotamian oil to the Mediterranean, which meant the British could still be denied access to Mesopotamian oil. The eventual solution, which involved a long row between Britain and France that culminated in intervention by Standard Oil, was to bifurcate the pipeline at Haditha, with one branch to Tripoli in French controlled Syria and the other through British controlled Transjordan to Haifa in British controlled Palestine (Cadman 1934; Fitzgerald 1993).

SOCAL, later the Arab American Oil Company (Aramco), now Chevron, recognized that oil was present in Bahrain in salt-domes of the sort it was familiar with in California and which one of its partners, the Texas Company, later Texaco, had come to understand empirically at Spindletop. SOCAL cleverly circumvented the Red-Line and Achnacarry Agreements, recognized that Saudi Arabia was a massive potential site for salt-dome deposits, and was able to persuade King Ibn Saud, who was no friend of Britain, to lease Saudi Arabia's potential oil fields to them. Like Standard Oil of New Jersey APOC and IPC had no understanding of salt-dome geology, believing oil was exclusively found trapped in porous rock formations. Shell, one of the main constituent companies of IPC, refused to participate in any lease negotiations in Saudi Arabia since it "did not regard the prospects as favourable from either a geological or a political point of view" (Fitzgerald 1991: 458). SOCAL's final success was in policy. They were able to get President Franklin D. Roosevelt to visit Saudi Arabia on his return from the Yalta Conference in 1945, cementing a close relationship between the Saudi

monarchy, America, and Aramco that guaranteed America access to the Middle East's most prolific oilfields (Yergin 1991).

3 Ideas and Reality: Oil Fuel, Naval Power, and the Merchant Marine

Tied up with the "oil exhaustion" argument of the 1920s was the realization that oil-fuelling of ships had become central to the development and retention of global power at both a military and an economic level. By the 1920s three main strands in the innovation of oil-fuelling were apparent. The first was in naval vessels, where the advantages of oil fuel were quickly seen as out-weighing the costs. The second was in oil-fuelling of merchant steamships. The third was in the adoption of a radically new form of powerplant, the diesel engine, which seemed to offer very substantial advantages to merchant ship owners, in particular in range. There was early naval interest in using diesels to extend the cruising range of ships, but the attempt initiated in 1911 in Germany to build a 12,000 hp battleship engine was too far ahead of the metallurgy of the period and resulted in failure (Landahn 1925).

3.1 Innovations in Oil-Fuelled Shipping

The innovation of oil fuels for ships was clearly revolutionary, but the technologically oriented response of the engineers was very different from the response of those concerned with geopolitics. The engineers were very clear on the technological advantages of oil fuel, but also on its ability to destabilize the shipping industry:

"The old stable situation, where the problems were mainly non-engineering in character, and competition depended on crew wages and size within a given size of ship, on shipping management, and possibly on government cooperation, has for the moment entirely disappeared, and while some of the old problems remain, new ones have come forward and are to-day dominant. The new ones are the result of (a) the use of oil as fuel in competition with coal; (b) the steam turbine; and (c) the internal combustion engine" (Lucke 1921: 14).

The policy responses focused more on the issue of the supply of oil. As demand rose there were fears that supply might falter, fears expressed through the "oil exhaustion" thesis. Delaisi (1922) and de la Tramerye (1924) both argued that the British had robbed France of possible oil rights in Mesopotamia she should have had under Sykes-Picot-Sazanoff but was maneuvered out of at Versailles and, later, at San Remo. Both authors linked hegemony explicitly to a nation's ability to control the oil supply and to the strength of its merchant marine.

> The nation which controls this precious fuel will soon see the wealth of the rest of the world flowing towards it. The ships of other nations will soon be unable to sail without recourse to

Table 2 Steam versus diesel power for merchant shipping (de la Tramerye 1924: 15)

Powerplant	Diesel	Steam
Horsepower	2,100	2,100
Weight of engine and accessories	1,000 t	3,400 t
Space required	5,300 m^3	10,000 m^3
Daily fuel consumption	100 t heavy oil	360 t coal
Consumption for a voyage of 15 days	1,500 t	5,400 t
Bunker space for a voyage of 15 days	1,700 m^3	7,000 m^3
Total space required for engine and fuel	7,000 m^3	17,000 m^3

> its stores of oil. . .[T]he nation which obtains the world's carrying trade takes toll from all those whose goods its carries, and so has abundant capital. . .At one stroke the controlling centre of the world's credit is displaced. This is what happened already in the eighteenth century when, with the development of British shipping, it passed from Amsterdam to London (de la Tramerye 1924: 10–11, based on Delaisi 1922: 2).

De la Tramerye's argument focused on the technological advantages of the diesel engined merchant ship, illustrated in Table 2. The horsepower rating given in the original as 21,000 is incorrect. No diesel that powerful had run by that time and steamships of that power would not be cargo liners. The two engines used in the first diesel engine motor ship, *Seelandia*, generated just over 2,000 hp in total, so one should assume de la Tramerye meant 2,100 hp. His other figures are consistent with other sources.

For oil firing of steam ships, there would be a reduction "by 70–80 %. of the stokers since a single man can look after several boilers. [For diesels the labor savings would be even greater]. The fuelling of the ship is effected cleanly and quietly in a few hours. Hundreds of tons of oil can be pumped into the cisterns in a negligible time, and that even at sea and in heavy weather. . .In the latest Cunard and White Star liners the economy of space thus realized has been as much as 33 %" (de la Tramerye 1924: 16–17).

The popular press had begun to point out the technical advantages of diesel engines much earlier than the "oil exhaustion" advocates. The first successful ocean-going motor ship was, appropriately, *Vulcanus*, an oil tanker built in 1910 for the Anglo-Saxon Petroleum Company. Such ships would use far less fuel for the same amount of work, have more usable cargo space, need less labor, and be much more rapidly refuelled (Carter 1911: 592–594). The first really notable motor ship was, however, *Seelandia,* which was built for the Far Eastern run where the range made possible between refueling mattered. *Seelandia* made her maiden voyage in 1912, and marked "the most striking advance at this time" (Smith 1938: 330).

3.2 Oil and Naval Power

As early as 1908, in *Oil Fuel and the Empire*, J. D. Henry, British author and founder of the journal *Petroleum World*, noted that "recognising that in swift ships

oil saves time and labour, if it does not save money, the Admiralty has decided to use oil fuel in every type of warship, and it is this fact which gives the imperial aspects of the subject such tremendous importance" (Henry 1908: 16). In the run-up to World War One navalists such as Winston Churchill began to see oil-firing of steam turbine engine warships as a highly desirable technology that would substantially increase the fighting capacity of naval vessels by allowing higher speeds and radically easier refueling, plus lowered weights through lighter fuel and a substantial reduction in stokehold crew size, thus more armor plate and bigger guns. In 1913 Churchill oversaw the acquisition of APOC by the British state and it was such policies that pushed Britain into the acquisition of Mesopotamia as a source of oil that would be securely within the Empire (Yergin 1991).

3.3 Oil Firing of Merchant Ships

Before 1914 operators of merchant vessels began to follow a similar line regarding oil-firing for the new steam turbine powered ships coming to dominate the Atlantic shuttle by virtue of their speed. Such ships, like their warship cousins, used direct-drive turbines, which required a great deal of fuel. Smaller merchant ships, however, stuck with the more fuel efficient triple-expansion reciprocating steam engine and coal fuel until around the outbreak of World War One. One of the aftermaths of the war was, however, that constant strikes at the mines and the docks meant that from 1918 to 1920 coal prices rose faster than oil: "between 1919 and 1922 the tonnage of steamers fitted for oil-firing rose from 5.3 million to 14.5 million [tons]" (Henning and Trace 1975: 382).

The year 1914 was something of a watershed. "The geared turbine, the turbo-electric drive, and the Diesel engine made their appearance almost simultaneously around 1913 and by 1917 the triple-expansion and quadruple-expansion steam engine began to feel the competition of the Diesel engine and the geared turbine" (Chapman 1942: 110). The diesel-engined motorship burned only oil, the steam turbine ship mostly oil. American shipyards turned out a huge tonnage of basic merchant ships during World War One, the majority using reciprocating steam engines but increasingly burning oil. By 1920 56 % of the American merchant fleet burned coal and 44 % oil (USDC 1960: 444). When the war was over there was a steady shift to geared turbines and oil fuel. American shipbuilders, however, generally avoided diesels.

3.4 Diesel Engined Motor Ships

Before World War One steam engines were clearly important to the adoption of oil as a maritime fuel but in that same period the utility of the diesel engine also became apparent. Even in their early form diesels were ideally suited to powering

merchant ships, particularly where long range was needed. *Seelandia's* sister ship, *Fionia*, re-named *Christian X*, was reported on in the *New York Times* upon its arrival in New York on its maiden voyage: "the steamship requires recoaling four times to circle the globe…A fuel consumption of between nine and ten tons for each day…makes it possible for the *Christian X* …to make a continuous voyage around the world without replenishing her tanks" (Bogert 1912: 4). Motor ships did not offer high speed but they did offer substantial savings in fuel and stoke-hold labor costs as well as greater cargo capacity for a given tonnage (Table 2).

World War One proved to be a huge technology forcer in the area of diesel engines. Although the French navy was the first to use diesels in submarines the Germans quickly followed. During the war half Germany's "submarines ran on MAN's four-stroke diesels, mostly 1,200-hp units" (Smil 2010: 71). At the war's end the availability of a large number of such engines as war surplus helped speed the transition to an increasingly diesel powered merchant marine (Smith 1938, 337). By 1939 24.4 % of the world's merchant ships were powered by diesels. It was, however, the Scandinavian countries and Holland that most rapidly adopted diesels. By 1939 Norway led, with 62.2 % of its merchant fleet powered by diesels: Denmark was at 52.2, Sweden at 46.6, and Holland at 45.5 %. By contrast Britain was at 25.6 and Germany only at 26.2 %: even Japan surpassed those figures with 27.2 % of its merchant ships diesel powered (Henning and Trace 1975: 354).

America was much slower to adopt diesels than oil fuelling, in part because of the protectionism of the Jones Act. In 1940 69 % of American merchant ships were oil-burning steamships whereas less than 11 % used diesels (USDC 1960: 444). Adolphus Busch had licensed Diesel's engine as early as 1897 and in 1898 installed one to power his brewery in St Louis, MO (Krebs 1953). The Swiss company, Sulzer, licensed Diesel's engine in 1898 and joined forces with Busch in the American market. Initially Busch-Sulzer focused on the demand for diesels by local electricity generating stations. When America entered World War One the Navy had them develop submarine engines and after the war they moved into marine diesels. Even so, in the mid-1920s, out of fifteen manufacturers of diesel engines worldwide, only two, Bethlehem and Worthington, were American companies building American designed diesels, and neither was successful (Hardy 1926: 308).

A second reason for the slower American adoption of diesels was that the American economy of the early 1920s still lacked some of the skills needed to manufacture and maintain them. Diesels operated at much higher internal pressures and temperatures than even the most sophisticated steam engines, and thus required very high levels of manufacturing skill and excellent metallurgy that increased first cost. Other than Busch-Sulzer the first major American company to enter the market for diesels was General Motors, which did so in the early 1930s via its acquisition of the Electro-Motive Corporation (EMC) in 1930, re-named Electro-Motive Diesel (EMD) in 1941. By the late 1930s EMC had an efficient diesel engine at work in railroad locomotives, and in World War Two EMD turned its attention to marine diesels (Schramm 2010).

4 Conclusion

Commentators in Britain and America by the early 1920s were clear on the relationship between the developing struggles foreseen by Wilson in the arenas of marine transportation and petroleum. They argued that whoever controlled the right mix of marine transportation technology, in particular that of the merchant marine, and petroleum supply would control the emerging post-war international order. However, the ideas that were put around in the early 1920s with regard to the development of petroleum and shipping did not fully mesh with the realities that were apparent by1945. Four major technological and economic forces intervened to prevent clear American victory in this struggle, although in general America did better than Britain.

First, the “oil exhaustion” thesis of the early 1920s faded rapidly as new American oilfields came on line in the 1930s and oil production finally began in Persia and Iraq. Britain’s policy advantages in the Middle East evaporated for three reasons. American companies such as SOCAL and The Texas Company developed practical experience with salt-dome oil deposits, while theoretical understanding of these was developed by geologists at Louisiana State University and at the University of Texas’ Bureau of Economic Geology. British companies involved in the Middle East failed to understand the importance of salt-dome deposits and effectively denied their existence. Finally, sound diplomacy brought Saudi Arabia’s massive oil reserves under American control by 1945. Despite fears in the 1920s that America might lose its grip on the global oil supply, from 1930 to 1945 that grip substantially tightened.

Second, although America remained the dominant global supplier of oil, America failed to capitalize on the remarkable increase in its ship building capacity that had been developed in World War One, failed to adopt the diesel engine for its merchant ships when the war was over, and never challenged British dominance of the world’s merchant marine in the period between World Wars One and Two, however much that dominance slipped. In 1894 Britain built 79 % of the 1,323,538 t of merchant ships launched that year, America only 5 % and Germany just under 9. In 1919 7,144,549 t were launched, with America accounting for 57 % and Britain just under 23 %. Of the 2,117,924 t launched in 1936 Britain built just over 40 %, America just over 5 and Germany 18 %. Wilson’s vision of an American merchant marine fell apart for three reasons. First, the ships built in a hurry during World War One were outdated technologically by the end of that war. Too many ships were coal-fired, triple expansion engine ships, and by 1919 oil fired, geared turbine engine ships and diesel engine motor ships were rapidly taking their place. Second, the fleet of passenger ships that Wilson hoped would compete for traffic on the lucrative Atlantic routes dominated by Britain were a mixed bag of largely German ships interned in American ports in 1914 and seized as war prizes when America entered the war in 1917. Such ships were stylistically and technologically outdated by 1920. Finally, few well-off passengers were willing to take passage on an American ship after Prohibition made American ships legally “dry” in 1919.

Third, the success of the motor ship encouraged by the 1930s significant improvements in the fuel efficiency of the oil-fired steamship that brought its specific fuel consumption much nearer to that of the diesel engine motor ship. The combination of superheated steam and higher boiler pressures allowed substantial increases in fuel efficiency in steam turbine engine ships. Whereas in 1919 the best such ships consumed one pound of fuel per horsepower hour and diesels 0.42 lbs., by 1940 those figures were 0.60 and 0.38 lbs. respectively (Chapman 1942: 249). The one strength of American merchant shipping in the 1919–1939 period was the refinement of the geared turbine, oil-fuelled steamship. Unfortunately this was ultimately a technological dead end, and an analysis such as Chapman's based only on engineering criteria was not realistic in the light of the real world of merchant shipping.

> The motorship's great advantage was in cargo carrying capacity…this additional cargo capacity accounts for the greater profit earned by motorships in the 1920s and early 1930s. Note also that whereas the proportion of the motorship's capacity required to be filled in order to break even varied between 67 and 91 %, there were years in which it was impossible, given freight rates ruling, for either the coal- or oil-fired steamships to break even (Henning and Trace 1975: 375).

Fourth, the price of refined diesel fuel moved against the price of the unrefined bunker C fuel that was burned in oil-fired steamships. By 1941, and corrected "for the differences in specific gravities of the two fuels…the ratio of fuel costs per ton… = 1.64" (Chapman 1942: 250). Given that the ratio of fuel use was 0.60 to 0.38, or 1.58, the oil fuelled turbine engine steam ship held a cost advantage. This, the Jones Act, and the short-haul geography of American shipping between American ports encouraged American shipping lines to stay with the geared turbine when they should not have. A diesel engine could run on bunker C fuel as well as the more refined and expensive diesel fuel as long as bunker C was pre-heated so it atomized properly. It was much harder to start and needed more maintenance, and American engineering texts of the 1940s were skeptical of its utility (Chapman 1942: 251).

The simple fact is that America maintained a huge advantage over Britain between 1919 and 1947 in the struggle over petroleum, and this despite the initial policy success of Britain in the Middle East. Where America failed was that it signally failed to capitalize on the advantages in international merchant shipping that it should have enjoyed as it emerged from World War One. In both cases technology played a major part. American success in Saudi Arabia was based on the development at SOCAL of the technology to exploit salt-dome deposits of oil. The failure in merchant shipping was the American failure to see the central importance of Diesel's radical new engine.

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